NOTICE

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Federal Aviation Administration

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Cancellation
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SUBJ: GUIDELINES FOR THE APPROVAL OF SOFTWARE CHANGES IN LEGACY SYSTEMS USING RTCA DO-178B

1. PURPOSE. This notice provides guidelines to Aircraft Certification Service (AIR) field offices and to Designated Engineering Representatives (DER) regarding the application of RTCA DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," to software for systems that were developed prior the issuance of Advisory Circular (AC) 20-115B, "Radio Technical Commission for Aeronautics, Inc. Document RTCA/ DO-178B," on January 11, 1993. These systems are referred to as legacy systems throughout this notice and refer to systems developed under DO-178 or DO-178A. AC 20-115B recognizes DO-178B as an acceptable means of compliance for the evaluation of software in airborne systems. DO-178B guidance for legacy systems is frequently misinterpreted and is not being consistently applied. This notice does not change the intent of DO-178B with regard to legacy systems but clarifies the application of DO-178B. Notice 8110.53, "Transition to RTCA/ DO-178B, 'Software Considerations in Airborne Systems and Equipment Certification,'" was originally released to address this issue but did not meet all of the needs of the industry and certification authorities. This new notice should be used to apply DO-178B to legacy systems.

2. DISTRIBUTION. This notice is distributed to the branch level in Washington Headquarters Aircraft Certification Service, section level in all Aircraft Certification Directorates, all National Resource Specialists (NRS), all Aircraft Certification Offices (ACO), all Manufacturing Inspection Offices (MIO), all Manufacturing Inspection District and Satellite Offices (MIDO and MISO), and all Flight Standards District Offices (FSDO). Additional limited distribution should be made to the Air Carrier District Offices, the Aeronautical Quality Assurance Field Offices, and the FAA Academy.

3. RELATED PUBLICATIONS.

a. Advisory Circular 20-115B "Radio Technical Commission for Aeronautics, Inc. Document RTCA/DO-178B," dated January 11, 1993.

b. RTCA DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," dated December 1, 1992.

c. Notice 8110.53, "Transition to RTCA/DO-178B, 'Software Considerations in Airborne Systems and Equipment Certification,'" dated September 29, 1994.

4. BACKGROUND. On January 11, 1993, the FAA issued AC 20-115B which recognizes DO-178B as a means to secure FAA approal of digital computer software. Prior to the issuance of AC 20-115B, many airborne systems were approved using DO-178 or DO-178A. These

systems are referred to as legacy systems throughout this notice. Since AC 20-115B invokes DO-178B, many manufacturers are striving to use DO-178B on their legacy systems. There are several items to keep in mind when addressing the use of DO-178B on legacy systems:

a. DO-178B is different from the two previous versions of DO-178. The major change from the previous versions is the emphasis on a set of coordinated objectives rather than a collection of unrelated goal statements. There is also a change from an emphasis on documentation to a emphasis on objectives and the data needed to demonstrate compliance to those objectives. Software testing is the most visible difference between DO-178B and previous versions. Therefore, legacy systems approved under a previous version would not have the same level of testing assurance as that required by DO-178B (i.e., DO-178B clarifies the scope and extent of software testing and test coverage). AC 20-115B effectively cancels all previous versions of DO-178. Therefore, changes/modifications to systems accepted prior to the issuance of AC 20-115B or the migration of these systems to newer aircraft will be evaluated using DO-178B. Misinterpretations of the guidance of DO-178B regarding legacy systems have resulted in inconsistent application of the guidance, resulting in differences in efforts expended for similar changes. The issuance of Notice 8110.53 attempted to correct this problem but did not due to its inherent complexity.

b. Another difference between DO-178B and earlier versions is the classification of software levels and the need to perform a safety assessment to determine the software level. Previous versions only recognized three software levels, whereas DO-178B recognizes five software levels. There is no guidance that provides correspondence between these levels. This notice will provide a method to establish that correspondence. Once the correspondence has been established, then guidance provided by DO-178B may be applied to upgrade from a lower level to a higher level.

c. Prior versions of DO-178 do not address the qualification of tools. In many cases tools are involved in making changes to legacy systems. Therefore, modification projects for legacy systems are faced with the issue of how to address tools that were used and not evaluated as part of the original approval. The subject of tool qualification will not be specifically addressed in this notice but will be addressed in future policy.

d. After reviewing field experience with numerous changes, a procedure was developed to provide a more consistent approach to address changes to legacy systems. The approach described herein takes advantage of previous approvals while ensuring that changes are properly implemented and satisfy current FAA regulations and guidance.

> NOTE: If the system contains multiple levels of software, the procedure should be applied to each of the partitioned sections that is affected by the change.)

5. DISCUSSION.

a. If the software level of the legacy system cannot be shown to be equivalent or better than that required by the installation being considered, then the software will have to be upgraded in accordance with procedures defined in DO-178B Section 12.1.4, "Upgrading a Development Baseline." This will require a complete reevaluation to demonstrate assurance to the appropriate objectives of DO-178B. Determining equivalence is addressed in Section 6 of this notice; however, application of DO-178B Section 12.1.4 is not addressed further in this notice.

b. There are four variables that can affect the actions needed in response to changes to legacy systems: (i) the assurance basis for original installation of the component containing the legacy software, (ii) whether DO-178B or previous version is the accepted means of assurance on the installation under consideration, (iii) whether the software is being modified or unchanged, and (iv) whether the software is being installed on the same or a different aircraft. Assuming that the software levels can be shown to be equivalent, the majority of legacy system issues of concern can be categorized into the following groups:

(1) Legacy systems software is not modified and is reinstalled on the original aircraft (to be addressed in section 6b of this notice).

(2) Legacy systems software is not modified but is installed on a different aircraft where DO-178B is not adopted as the means of demonstrating assurance (to be addressed in section 6b of this notice).

(3) Legacy systems software is modified and is reinstalled on the original aircraft (to be addressed in section 6c of this notice).

(4) Legacy systems software is modified and is installed on a different aircraft where DO-178B is not adopted as the means of demonstrating assurance (to be addressed in section 6c of this notice).

(5) Legacy systems software is modified and is installed on a different aircraft where DO-178B is adopted as the means of demonstrating assurance (to be addressed in section 6d of this notice).

(6) Legacy systems software is not modified but is installed on a different aircraft where DO-178B is adopted as the means of demonstrating assurance (to be addressed in section 6e of this notice).

c. Legacy systems, by definition, already have a recognized approval for installation or manufacturing through the Type Certificate (TC), Supplemental Type Certificate (STC), Amended Type Certificate (ATC), Technical Standard Order Authorization (TSOA), Production Certificate (PC), or Parts Manufacturer Approval (PMA) processes. If there are no changes to these systems, then the original approval of the software is still valid, assuming an equivalence to the required software level can be ascertained (to be further discussed in Section 6 of this notice). Prior to installation in an aircraft, there should be some assessment that the systems are not going

to be used in significantly a different manner than covered by the original installation approval. This notice does not address TSOA, since they are covered by Title 14 Code of Federal Regulations (14 CFR), Part 21, Subpart O and the governing Technical Standard Orders (TSO), as well as other policy from the Aircraft Certification Service Engineering Division (AIR-100). Although the information within this notice may be of use in evaluating changes to software-based products with TSOA, this notice was not written to address TSOA issues.

d. Systems with small, simple changes (e.g., gain changes where the new gain is within a band of gain settings originally tested, changes to maintenance information formatting, adding an additional output interface, changing data in a personality module that is within the original robustness test cases, etc.) should be handled as changes under the original approval basis (i.e., DO-178B does not need to be applied to the changes). The certification authority should be able to readily establish that these changes have been performed correctly under the original approval basis. The normal data submittals appropriate to the revision of DO-178 used for the original certification will still need to be evaluated to ensure that the changes are implemented correctly. If this cannot be done, then this is not a small, simple change. The determination of whether a change is small, simple cannot be made by objective considerations such as metrics or a count of lines of code. Therefore, this determination will be based on the individual judgment of the cognizant Aircraft Certification Office (ACO) Aviation Safety Engineer (ASE) or the Designated Engineering Representative (DER) making the evaluation (if the DER is delegated this authority).

NOTE: This process of allowing small, simple changes should not be followed, if the system is being used differently than the original certification project, or if the system has experience service difficulties.

e. When changes are made to legacy systems beyond the small, simple changes, assurance that the changes have been made properly will be required. The following items should be considered:

(1) Earlier versions of DO-178 do not contain well-defined acceptance criteria for a number of the requirements/guidelines. One example is in the area of testing. DO-178B requires that testing be sufficiently thorough to provide specific structural coverage criteria, whereas DO-178A only requires that testing exercise the logic but does not specify how extensively the logic be exercised.

(2) Additionally, some newer technologies and tool qualification are not even addressed in the earlier versions of DO-178. In all cases where ambiguities exist, the material in DO-178B will be used to provide a more exact interpretation.

(3) To be consistent with prior approvals, DO-178B should be used to evaluate the processes used to make the change, the changed software components, and those components affected by the software changes. Affected components should be identified by performing a change impact analysis of the software changes and identifying impacts on other components, interfaces, timing, memory, etc. (e.g., control coupling analysis, data coupling analysis, timing

analysis, memory usage analysis, etc.). These analyses should also identify the level and extent of regression testing needed to verify the change.

(4) The unaffected portions of the software already have an approval basis and could be accepted in accordance with Section 5c of this notice. (It should be noted that the unaffected portion is the software that neither changed nor was affected by the change via control, data flow, or timing. The change impact analysis is used to determine the affected and unaffected portions.) In most cases, the risk of latent errors remaining in the software can be further mitigated by considering the benefit of service experience in conjunction with the prior approval. DO-178B Section 12.3.5, "Service Experience," contains a number of criteria that should be satisfied to allow the use of service experience. By virtue of the previous approval of the software, it may be assumed as already meeting the majority of the provisions of DO-178B Section 12.3.5. Little or no additional data should be required from the applicant regarding service experience under Section 12.3.5. (Note: The note in paragraph 12.3.5g of DO-178B does imply that additional data may be required to verify system safety objectives for software components and should be appropriately considered.)

(5) Once the change has been approved, the entire software should be considered to be assured to DO-178B at the appropriate software level. If the original assumption that service experience in conjunction with a prior approval was incorrect, then a number of field problems might surface. Since the process for changes has been assured to DO-178B standards, the subsequent changes will be addressed using DO-178B. Eventually, this may potentially result in the entire software being evaluated to DO-178B.

6. PROCEDURES. For any project involving changes to a legacy system or a different installation for a legacy system, the cognizant ACO ASE and/or DER should follow the procedures listed in this section.

a. The ASE and/or DER should establish that there is equivalence between the legacy system's software level(s) and the proposed installation's software level using Table 1 below. Table 1 illustrates the equivalence between DO-178/DO-178A and DO-178B. Table 1 is designed as a truth table asking the following question: "If the Legacy System has a specific DO-178/DO-178A software level, can it be installed on the product requiring a certain DO-178B level?" For example, if the legacy system has DO-178A/Level 2 software, it can be installed on a product requiring DO-178B Levels C, D, or E. There are two entries in Table 1 that may require analysis prior to determining equivalency; these instances are shown by an "Analyze" in Table 1. There should be an agreement between the ACO and applicant, when analysis is required. If equivalency is not established by Table 1 (i.e., a "NO" entry in the table), the provisions of DO-178B Section 12.1.4 should be applied to upgrade the software level. Procedures for applying section 12.1.4 are not covered by this notice. The remainder of this notice assumes that equivalency has been established.

NOTE: Per 14 CFR, Part 21, §21.1(b), a "product" is an aircraft, an aircraft engine, or an aircraft propeller.)

Table 1 Software Level Equivalence

	Legacy System Software Level per DO-178/DO-178A		
DO-178B SW Level Required by the Installation	***Critical/Level 1***	***Essential/Level 2***	***Non-essential/Level 3***
A	**YES/Analyze**	**NO**	**NO**
B	**YES**	**NO/Analyze**	**NO**
C	**YES**	**YES**	**NO**
D	**YES**	**YES**	**NO**
E	**YES**	**YES**	**YES**

b. If the legacy system's software is unmodified and is being reinstalled on the same aircraft or a different aircraft where DO-178B is not required, then the original assurance process and associated data submittals may be accepted. This is only true if the system is being used in exactly the same way as originally certified, has no added functionality since the original certification, and has not experienced service difficulties (e.g., Airworthiness Directives, Service Bulletins, etc).

c. If the legacy system's software is modified and installed on the same aircraft or on a different aircraft where DO-178B is not adopted as the means of demonstrating assurance, then either the assurance means of the original aircraft or the assurance means of the original legacy system may be used, providing the one with the latest revision is used.

d. If the legacy system software is modified and installed on different aircraft where DO-178B is adopted as the means of demonstrating assurance, it should be assessed if the change is a small, simple change (as discussed in Section 5d of this notice). Any changes determined to be small, simple changes may be handled the same as the not modified case discussed in Section 6b of this notice. The determination of whether a change is a small, simple change shall be at the discretion of the cognizant ACO ASE and/or DER. Some representative, but not exhaustive examples, of small, simple changes are given in Section 5d of this notice. If the changes is not a small, simple change, all the changes to the software and all of the components affected by the change should be assured using DO-178B (as discussed in Section 5e of this notice). The change impact analysis is the normal means of determining affected components. A description of change impact analysis is beyond the scope of this notice. However, the project plans and processes and the change activities and evidences should be shown to meet the objectives of DO-178B. For example, if the original software was not evaluated using the structural coverage criteria in DO-178B Section 6 and Annex A, then DO-178B verification specified for the software level of the changed software will have to be done and coverage criteria satisfied. Additional affected, but unchanged, components may not have to be evaluated for logical structural coverage of the internal logic but would have to meet the requirements for data coupling and control coupling coverage (e.g., integration testing), as

well as requirements-based test coverage for those affected functions. Once this process is complete, the applicant should be allowed to claim that their legacy system is now compliant with the guidelines of DO-178B.

e. If the legacy system software is not modified but is installed on a different aircraft (i.e., different type certificate) where DO-178B is adopted as the means of demonstrating assurance, then there should not be a separate assurance finding. The original approval serves as the installation approval of the software, unless the operational use of the system is expected to be significantly different (e.g., an air data computer installed on piston powered general aviation aircraft flying below 14,500 feet is now installed on a corporate jet flying at 50,000 feet). When the operational use is significantly different than the original certification basis, an assurance to DO-178B guidance should be performed. The determination of the significance in change of the operational use shall be at the discretion of the cognizant ACO ASE and/or DER (if the DER is delegated this authority).

f. All changes to legacy systems and the process used to approve those changes should be documented in the Plan for Software Aspects of Certification (PSAC), Configuration Index Document (CID), and/or the Software Accomplishment Summary (SAS), as appropriate for the specific project.

g. If any future changes are proposed, they should be addressed by using the criteria specified in this notice.

7. CONCLUSION. The information and procedures described in this notice are meant to provide additional clarification and to promote consistent interpretation of the guidelines in DO-178B for approving changes to software in legacy systems. This notice does not replace or supersede AC 20-115B or DO-178B.

James C. Jones
Manager, Aircraft Engineering Division,
Aircraft Certification Service